Energy, Mines and Resources Canada

Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie

Mining Research Laboratories

Laboratoires de recherche minière

Canada

GEN3D USER'S GUIDE – A THREE–DIMENSIONAL MESH GENERATING/PLOTTING SYSTEM FOR SAP3D (VAX–11/750 VERSION)

N.A. Toews, Y.S. Yu and A.S. Wong

December 1988 MRL 88-103 (TR)

This document is an unedited interim report prepared primarily for ... Mines Branch report ... Published ... It does not represent ... final explanation of the opinions ... the Canada Centre for Mineral and Energy Technology (CANMET)

Ce document est un rapport ... provisoire non-révisé et rédigé principalement pour fin de diffusion et de documentation ... ne représente nullement ... définitive de l'opinion du Centre canadien de la technologie des minéraux et de l'énergie (CANMET)

MICROMEDIA

31 pp

89-06213/

GEN3D USER'S GUIDE - A THREE-DIMENSIONAL MESH GENERATING/PLOTTING SYSTEM FOR *SAP3D* (VAX-11/750 VERSION)

by

N.A. Toews*, Y.S. Yu* and A.S. Wong**

ABSTRACT

GEN3D is one of the component programs contained in the *SAP3D*, which is a static, linear elastic finite element (F.E.) program for analysis of three-dimensional (3-D) structures. It produces a 3-D finite element mesh file that is suitable for running the *SAP3D*.

GEN3D was originally developed for a CDC 6000 series computer and it has been modified and enhanced to run on a VAX-11/750 computer under VMS the operating system.

GEN3D only applies to a restricted type of 3-D structure, but is quite suitable for the massive structures commonly occurring in mining.

GEN3D is not only generating the input data file (SAPIN) for *SAP3D*, but is also capable of producing plots of all the sections of the 3-D mesh for visual inspection and mesh modification or producing report quality plots for publication.

Key Words: 3 dimensional, finite element, structure, plot

* Research Scientists, ** Physical Scientist, Mining Research Laboratories, CANMET, Energy, Mines and Resources Canada, Ottawa.

GUIDE DE L'UTILISATEUR DU GEN3D – UN SYSTÈME DE TRACAGE/PRODUCTION DE MAILLES TRIDIMENSIONNELLES POUR LE SAP3D (VERSION VAX-11/750)

par

N.A. Toews*, Y.S. Yu* et A.S. Wong**

RÉSUMÉ

Le GEN3D est un des éléments du SAP3D, un programme statique à éléments finis (E.F.) linéaires élastiques utilisé pour l'analyse de structures tridimensionnelles (3–D). Il produit un fichier de mailles à éléments finis 3–D qui peut être traité par le SAP3D.

À l'origine, le GEN3D a été écrit en vue d'être exécuté sur un ordinateur de la série CDC 6000, puis il a été modifié et amélioré en vue d'être exécuté sur un ordinateur VAX–11/750 avec le système d'exploitation VMS.

Le GEN3D ne s'applique qu'à un type restreint de structure 3–D, mais il convient très bien pour les structures massives qui sont courantes dans les activités d'exploitation minière.

En plus de créer le fichier de données d'entrée (SAPIN) du SAP3D, le GEN3D peut produire des graphiques de toutes les sections de la maille 3–D qui permettent de faire l'inspection visuelle et de modifier la maille; il peut aussi produire des graphiques de qualité rapport pour fins de publication.

Mots-clés: tridimensionnelle, élément finis, structure, graphique

* Chercheurs scientifiques, ** Chercheurs en sciences physiques, Laboratories de recherche minière, CANMET, Énergie, Mines et Ressources Canada, Ottawa.

CONTENTS

	Page
ABSTRACT	i
RÉSUMÉ	ii
1.0 INTRODUCTION	1
2.0 MSHGEN	2
3.0 BANDWIDTH CONSIDERATIONS	2
4.0 GEN3D PLOTTING FACILITY	2
5.0 COORDINATE AXIS	3
6.0 GEN3D FILE USAGE	5
7.0 MSHGEN INPUT DATA FOR TWO-DIMENSIONAL SECTIONS	5
8.0 GEN3D INPUT DATA INSTRUCTIONS	9
9.0 GEN3D 3-D FINITE ELEMENT EXAMPLE	17
9.1 MSHGEN Input Data	17
9.2 GEN3D Input Data	17
9.3 Initial Stress Coefficient Evaluation	26
10.0 GEN3D COMMAND PROCEDURE	28
11.0 REFERENCES	29
APPENDIX A	30
APPENDIX B	32

FIGURES

No.		
1.	MSHGEN Axis	4
2.	GEN3D Axis	4
3.	PLOTTER Axis	4
4.	Isometric View of the 3-D Model	18
5.	The 3-D Example Mesh Plot of Section 1, $X = 0$ m	19
6.	The 3-D Example Mesh Plot of Section 7, $X = 99$ m	20
7.	The 3-D Example Mesh Plot of Section 9, $X = 100$ m	21
8.	Sign Convention for Surface Loads	31
9.	Typical Finite Element and Codes for Face Identification	31

TABLES

1.	MSHGEN Data Input Instructions	6
2.	GEN3D Data Input Instructions	10
3.	Input Data for MSHGEN	22
4.	Input Data for GEN3D	26

1.0 INTRODUCTION

Three–dimensional (3–D) stress analysis using the finite element (F.E.) technique involves a large amount of input and output data. The construction of a 3–D mesh or the preparation of input data requires special skill and treatment. To assist the data preparation, a three–dimensional mesh generating system has to be adapted. *GEN3D* – a 3–D mesh generating system, was developed originally for a CDC CYBER computer, was modified and enhanced to run on a VAX–11/750 computer under VMS operating system. The *GEN3D* system is based on the concept underlying a two–dimensional (2–D) mesh generating program *MSHGEN* [1].

The discretization of a 3–D structure using the *GEN3D* system requires that the structure must first be divided into planar slices by a series of parallel planes (the normal to these planes defines the global X–axis). Each distinct section then has its nodal points and elements generated by the 2–D mesh generating program *MSHGEN* [1,2]. *GEN3D* then ties all these plane meshes together to form a 3–D finite element mesh of the structure suitable as input for the 3–D finite element stress analysis program *SAP3D* [3,4].

The major restriction in using *GEN3D* is the requirement that the number of nodal points and the number of elements shall be the same for all sections. Most mining structures are essentially infinite and it is necessary to truncate the structure by introducing fictitious outer boundaries and specifying outer boundary conditions; usually the excavation displacements along the outer boundaries are zero. In this case, there is no disadvantage in forcing these fictitious boundaries to be planar and forcing all sections to contain the same number of nodes and elements. Excavation sequence can still be introduced by assigning cut numbers (NCUTZ in *MSHGEN*) to appropriate elements. The concept of using 'cut' numbers to represent excavation sequences is fully explained in references [1,2].

A second assumption made in *GEN3D* is that the two outer planes in the X–direction have zero X–displacement, *i.e.*, the assumption is made that an outer surface is either a plane of symmetry or it so far away that the excavation displacement is approximately zero.

When a 3–D structure is divided into sections in the X–direction, the 3–D structure is said to have 'NUMSEC' sections which bound 'NUMSEC–1' slices. The 2–D mesh generating system (*MSHGEN*) will generate the co-ordinates of the nodal points, as well as the elements with associated material number and cut number. This element information is assumed by *GEN3D* to refer to the slice in the increasing X–direction.

2.0 *MSHGEN*

MSHGEN, the 2–D mesh generating program, is fundamental to *GEN3D*. The concepts necessary to understand, and the input data necessary to execute *MSHGEN*, are discussed in details in references [1,5].

MSHGEN must be executed J times (in a loop) to generate the required 3–D mesh. Two sections are distinct if they differ in any way, no matter how small this difference may be. Executing *MSHGEN* J times will produce a file containing J sub-files; *GEN3D* will merge all these sub-files and create an input data file (GENOUT) for *SAP3D*. In the 2–D *MSHGEN* system, a local coordinate system (ξ, η) is adopted for mapping. The appropriate choice of the (ξ, η) coordinates in *MSHGEN* is important in order to produce a 3–D mesh with a minimum bandwidth.

3.0 BANDWIDTH CONSIDERATIONS

When the 2–D sectional data *i.e.*, the nodal points and elements generated by *MSHGEN*, and merged by *GEN3D* system, it has to re-number these nodal points and elements. *GEN3D* assumes that the number of slices in the X–direction is smaller than the number of subdivisions in the other directions. Therefore, *GEN3D* numbers nodal points first in the X–direction, then increments in the ξ direction, and finally increments in the η direction. Therefore, the coordinate (ξ, η) should be selected as they are in 2–D finite element work to minimize the nodal point difference.

Suppose we have 'NUMSEC' sections in the 3–D mesh *i.e.*, we have 'NUMSEC−1' slices and suppose we have NSPAN1 subdivisions in the η direction in 2–D sectional mesh. Then the maximum nodal point difference in a 3–D element generated by *GEN3D* will be NUMSEC × (NSPAN1 + 2) + 1. An upper bound for the half bandwidth for the global stiffness matrix will therefore be 3 × NUMSEC × (NSPAN1 + 2) + 6.

4.0 *GEN3D* PLOTTING FACILITY

GEN3D not only produces an input data file (SAPIN) for *SAP3D*, but it also can optionally produce a plot of all sections making up the 3–D structure with the associated nodal point numbers and element numbers. The user can specify that all points within a given rectangle *i.e.*, the selected maximum and minimum Y, Z coordinates of the mode, be plotted. This allows for magnification of certain refined areas of the mesh. The same specified rectangle applies to all sections, *i.e.*, different rectangle cannot be specified for different sections. Similarly, it is possible to plot only the exterior of a specified rectangle for all sections. Thus, certain overly refined area of the mesh can be excluded from plotting.

5.0 COORDINATE AXIS

Different coordinate systems are used in *MSHGEN*, *GEN3D* and for plotting. To avoid any confusion, the discussion below hopefully will clarify this somewhat.

MSHGEN, which produces sections normal to the *GEN3D* X–axis, uses a right handed $X - Y$ system which we will denote below by X_{2D} and Y_{2D} (Figure 1).

The coordinate system for *GEN3D*, is also a right-handed $X\ Y\ Z$ system with the Z–axis being vertically upward and the axis for any applied gravity forces (Figure 2). The *GEN3D* Y–axis corresponds to *MSHGEN* X_{2D} axis and Z–axis corresponds to Y_{2D} axis.

Note that the plane sections to be generated by *MSHGEN* must enter in a sequence with increasing X–coordinates in the *GEN3D* system.

Figure 3 shows the correspondence of the X and Y plotter axes labelled as X_{PLT} (along the plot paper), and Y_{PLT} (across the paper). The Z–axis in *GEN3D* is plotted in the Y_{PLT} plotter direction and the Y–axis in the X_{PLT} plotter direction.

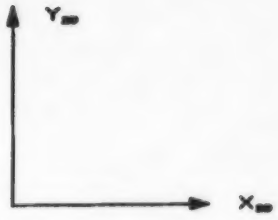


Figure 1. MSHGEN Axes.

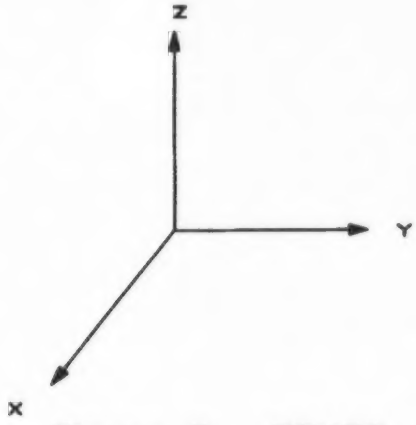


Figure 2. GEN3D Axes.

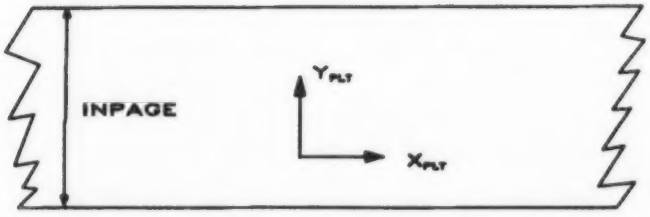


Figure 3. PLOTTER Axes.

6.0 *GEN3D* FILE USAGE

Five files are used in *GEN3D*. These are as follows :–

Logical File Name	Description
1. MSHIN	The file contains the mesh data for a total J sections generated by *MSHGEN*.
2. GENIN	The *GEN3D* input data file.
3. SAPIN	The file contains the input data for *SAP3D*. *GEN3D* takes MSHIN and merges with additional data (GENIN), which will be described below, and produces SAPIN which is acceptable by *SAP3D*.
4. FOR005	Interactive SYS$COMMAND data input only when CALCOMP plotter is used.
5. FOR006	The *GEN3D* print–output file.

7.0 *MSHGEN* INPUT DATA FOR TWO–DIMENSIONAL SECTIONS:

The concepts involved and procedures used in *MSHGEN* have been discussed in detail in reference [2]. It is recommended for any users who are not familar with *MSHGEN* study this reference.

The input data required for *MSHGEN* is outlined below and is subdivided into the following units:

(a) Title and problem control information,

(b) Block of data defining specified nodal points, and

(c) Block of data defining zones.

The input data required for each distinct section is described in the following Tables 1a–1c. All the formats for data entry are list-directed, i.e., free format. Note that for free format, the character string must be quoted, *i.e.*, it begins with a quote (') and ends with a quote (').

Table 1a

Group (a) - Problem Identification and Control Data:		
Variable(s)	Variable Definition or Description	Format
Record No. 1 – Number of distinct section:		
NMESH	Number of distinct mesh section to be generated.	
Record No. 2 – Problem title information:		
HEAD	80 character string of problem title.	
Record No. 3 – Problem control information:		
NSPNP	Total number of specified nodal points.	
NVZONE	Total number of non-void zones.	
NSPAN1	Total number of Spans in ϵ direction.	
NSPAN2	Total number of spans in η direction.	
NPROB	The total number of subproblems or incremental mining steps making up the excavation and or construction sequence. Default value is 1.	
NSIDNT	Identification indicator, a value of zero or blank means no identification; NSIDNT = 1, indicates identification. Default = 0 for most of the meshes generated.	
Record No. 4 – data defining zone subdivisions:		
NSBDV1(I)	Array defining number of subdivisions in each zone in ξ direction.	
BSBDV2(I)	Array defining number of subdivisions in each zone in η direction.	
Remarks:		

Table 1b

Group (b) – Block of Data defining Specified Nodal Point:
A total of 'NSPNP' records will follow.

Variable(s)	Variable Definition or Description	Format
	Record No. 1 – Coordinates of Specified Nodes:	
N	Specified nodal point number.	
NCODSP(N)	Constraint code of specified nodal point N. The table below defines the possibilities: NCODSP(N) — Constraint at Node N 0 — No constraint on displacements. 1 — x-displacement = 0. 2 — y-displacement = 0. 3 — x-displacement = 0, y-displacement = 0.	
XSP(N)	x-coordinate (horizontal) of node N.	
YSP(N)	y-coordinate (vertical) of node N.	
	Group (c) – Block of Data Defining Non-void Zones: For each non-void zone the following records must be entered.	
N	Non-void zone number.	
IZ(,N)	Nodal number defining non-void zone N. (see Note 1)	
MATZ(N)	The material number associated with the non-void zone N. the default value is 1. (see Note 2)	
NCUTZ(N)	The cut number associated with non-void zone N. If blank or zero is assigned the value 'NPROB + 1', i.e., the element in this zone will never be removed or excavated. (see Note 3)	
NUMPC	The number of sides (0-4) of non-void zone with pressure applied, i.e., a total of 'NUMPC' records defining pressure loading will follow immediately.	
Remarks:	Continued over the following page.	

Table 1c

Group (c) - Block of Data defining Non-void Zones (continued).		
Variable(s)	**Variable Definition or Description**	**Format**
Record No. 2 – Required only if NUMPC is greater than zero the the above data is followed by 'NUMPC' records defining pressure on the sides of zone N as follow:		
NSIDE	The side number of the zone N. See Figure 5 for the number associated with sides.	
P1	The pressure at node 1 of zone side 'NSIDE'.	
P2	The pressure at node 2 of zone side 'NSIDE'.	

Remarks:

Note 1: Zone Specification:
The corner nodes must always be specified. Intermediate nodes of zero or blank are assumed by *MSHGEN* to be mid-point nodes. Once the global (ξ, η) reference system has been selected then the order in which nodes are specified is rigid. Order of specification is counter-clockwise starting with the node at (MIN(ξ), MIN(η)).

Note 2: Material Specification:
Different materials should be given numbers 1 to NUMMAT, where NUMMAT is the number of different materials. The reason for this is that *MSHGEN* assumes that maximum material number equals the number of different materials.

Note 3. Cut Number:
Excavation and or construction sequences can be simulated by assigning a cut number to a zone. All elements in a zone will be removed when the subproblem number or incremental mining step number equals the cut number. A cut number of one (1) means that elements in this zone will not be used. Elements with cut number greater than 'NPROB' (the maximum number of subproblem) will not be deleted.

8.0 *GEN3D* INPUT DATA INSTRUCTIONS:

The input data required by *GEN3D* can be divided into nine groups, namely:

(a) Problem title and plot control information

(b) Records defining sections in a 3–D mesh

(c) Plotting device and control parameters

(d) *SAP3D* input control parameters

(e) Element distributed loads

(f) Initial stress coefficients

(g) Material properties

(h) Surface loads

(i) Concentrated Load.

The detailed input data is described in the following Tables 2a–2g:

Table 2a

Group (a) – Problem Title and Plot Control Information:		
Variable(s)	**Variable Definition or Description**	**Format**
Record No. 1 – Problem title record:		
TITLE	80 characters title name.	A80
Record No. 2 – Plot control parameter information:		
NUMSEC	Number of sections in the X–direction.	I5
NPLOT†	Plot indicator: If NPLOT = 1, all sections are plotted; If NPLOT = 0, no sections are plotted.	I5
SCALE	Coordinate scale factor. The default value is SCALE = 1.0.	F10.0
Group (b) – Records Defining Sections: With each section there is associated NUMSEC records.		
Record No. 1 – Section Data:		
K	The section number. Section number must be in sequential ascending order starting with K = 1 and ending with K = NUMSEC.	I5
NSQRSS(K)	The *MSHGEN* file number from which data for the K^{th} section is to be taken.	I5
XSEP(K)	The X–coordinate to be associated with section K. Sections must be in increasing X–coordinate order.	E15.7
Remarks: †: If NPLOT = 1, Group (c) data is required.		

Table 2b

Group (c) – Plotting Device and Control Parameters (Optional†):		
Variable(s)	**Variable Definition or Description**	**Format**
Record No. 1 – Plot legend parameter record:		
MUNIT	1-3 characters string that identifies the unit of the plot.	A3,2X
PLTDEV	3 character string that identifies the plot device. Available devices are : TEK – Tektronix Plot10 graphic terminal; CAL – Calcomp 1042 plotter.	A3,2X
CORVAL	Coordinate scale factor to be shown on the plot legend.	F10.0
THIT	Character height of the plot legend. Default value is THIT = 0.07 inch.	F10.0
Record No. 2 – Plot parameter record:		
FACTOR	Scale factor used in plot (inches / model coordinate unit). If FACTOR = 0, FACTOR is calculated by program.	F10.0
IBND	Plot region indicator: If IBND = 0, Plot whole section; If IBND = 1, Plot interior specified rectangle; If IBND = 2, Plot exterior specified rectangle.	I5
INPAGE	Width of plotter paper (inches). Default value is INPAGE = 28 inches.	I5
HITE	Character height (inches) to plot nodal numbers and element numbers. Default value is HITE=0.07 inch.	F10.0
ANGLE	Angle (°) with respect to the plotter X–axis at which nodal number are to be plotted. Default value is ANGLE = 45° .	F10.0
NELSKP	Element skip number: If NELSKP = 0, no element numbers are plotted; Otherwise, every NELSKP numbers are plotted.	I5
NODSKP	Nodal point skip number: If NODSKP = 0, no nodal points are plotted; Otherwise, every NODSKP numbers are plotted.	I5
Remarks: †: If NPLOT = 0, Skip to Group (d)		

Table 2c

Variable(s)	Variable Definition or Description	Format
Record No. 3 – Specified rectangle record for mesh plot:		
YMIN	Minimum Y–value of rectangle in logical unit.	F10.0
YMAX	Maximum Y–value of rectangle in logical unit.	F10.0
ZMIN	Minimum Z–value of rectangle in logical unit.	F10.0
ZMAX	Maximum Z–value of rectangle in logical unit.	F10.0
Group (d) – *SAP3D* Input Control Parameters:		
Record No. 1 – *SAP3D* problem title information:		
HEDING	80 characters *SAP3D* heading.	A80
Record No. 2 – *SAP3D* parameter record:		
NMAT	Number of different materials.	I5
NPRNTI	*SAP3D* print input data indicator. If nonzero, input data will be printed by SAP3D.	I5
NPRNTD	*SAP3D* print displacement data indicator. If nonzero, *SAP3D* will print displacement output.	I5
NPRNTS	*SAP3D* print stress data indicator. If nonzero, *SAP3D* will print stress output.	I5
NOSL†	Number of surface load sets indicator. The default value is NOSL = 0.	I5
NPROB	Number of subproblem to be executed by SAP3D. The default value is NPROB = 0.	I5
NRES	Initial stress indicator. If nonzero, initial stress will be calculated by executing subroutine CALRS5.	I5
NTGRAT	Gaussian integration order used in numerically evaluating the element stiffness matrices in *SAP3D*. The default value is NTGRAT = 2.	I5
Remarks: †: If NOSL is greater than 0, Group (e) and Group (h) data are required.		

Table 2d

Group (e) – Element Distributed Load Data (Optional†):

Variable(s)	Variable Definition or Description	Format
Record No. 1 – Distributed load record:		
NEL1	The initial element number.	I5
LOD	Load set number for all the elements generated by NEL1. The default value is LOD = 1.	I5
N1	Number of elements generated on the inner loop. The default value is N1 = 1.	I5
NELICI	Element increment number for the inner loop. The default value is NELICI = 1.	I5
N2	Number of times the inner loop is executed. The default value is N2= 1.	I5
NELIC2	Element increment number for the center loop. The default value is NELIC2 = N1 * NELIC1.	I5

Remarks:

(1) NELIC1 and NELIC2 cannot be negative, *i.e.* starting with NELB = NEL1, element load data is generated for the following elements:

NELB, NELB+NELIC1, ... NELB+(N1-1)*NELIC1

then

NELB is incremented NELIC2 *i.e.* NELB = NELB+NELIC2 and another N element are generated as shown above. This loop is performed N2 times.

(2) *SAP3D* will only accept one surface load set record per element. Because of this *GEN3D* is set up in such a way that if load data for a given element is generated more than one, only the first one is kept. This means interior elements on the second side (says) would have correct load set data although the user would have to input load for boundary element using concentrated loads.

(3) The last record must be a BLANK record.

†: If NOSL = 0, Skip to Group (f)

Table 2e

Group (f) – Initial Stress or Pre-mining Information Data:		
Variable(s)	Variable Definition or Description	Format
Record No. 1 – Coefficient AX and BX		
AX,BX	Coefficients for normal stress σ_X	2E15.7
Record No. 2 – Coefficient AY and BY		
AY,BY	Coefficients for normal stress σ_Y	2E15.7
Record No. 3 – Coefficient AZ and BZ		
AZ,BZ	Coefficients for normal stress σ_Z	2E15.7
Record No. 4 – Coefficient AXY and BXY		
AXY,BXY	Coefficients for normal stress σ_{XY}	2E15.7
Record No. 5 – Coefficient AYZ and BYZ		
AYZ,BYZ	Coefficients for normal stress σ_{YZ}	2E15.7
Record No. 6 – Coefficient AXZ and BXZ		
AXZ,BXZ	Coefficients for normal stress σ_{XZ}	2E15.7

Remarks:

(1) The definition of these coefficients can be illustrated by the equations representing the initial or far field stresses.
See example given in Section 9.2 for detail estimation of the coefficients.

$$\sigma_X = AX + BX \times Z$$
$$\sigma_Y = AY + BY \times Z$$
$$\sigma_Z = AZ + BZ \times Z$$
$$\sigma_{XY} = AXY + BXY \times Z$$
$$\sigma_{YZ} = AYZ + BYZ \times Z$$
$$\sigma_{XZ} = AXZ + BXZ \times Z$$

(2) The Z is negative if global coordinate system directed in upward direction.

Table 2f

Group (g) – Material Properties: With each material there is associated NMAT records.

Variable(s)	Variable Definition or Description	Format
Record No. 1 – Data defining material properties:		
MATN	The material number. (These correspond with the element material numbers generated by *MSHGEN*).	I5
E	Young's modulus for this material.	E15.7
RNU	Poisson's ratio for this material.	E15.7
WHT	Weight density of this material.	E15.7

Group (h) – Surface Load Records (Optional†): With each surface load there is associated NOSL records.

Record No. 1 – Surface load data:		
LSNUM	Load set number.	I5
LODTYP	Load type indicator. LODTYP = 1, indicates a uniformly distributed load. LODTYP = 2, indicates a hydrostatic load varying linearly with Y coordinate.	I5
SIZLOD	Load size. LODTYP = 1, SIZLOD is the magnitude of the uniform load. LODTYP = 2, SIZLOD is the weight density of fluid.	F10.4
YCOORD	If LODTYP = 2, YCOORD is the Y–coordinate of the fluid surface.	F10.4
LMLOAD(1)	Element face number on which surface load acts.	I5

Remarks:

(1) See Appendix A for more detail description of *SAP3D* input requirements.

†: If NOSL = 0, Skip to Group (i)

Table 2g

Group (i) – Record(s) Defining Concentrated Load Data: (if any)		
Variable(s)	Variable Definition or Description	Format
Record No. 1 – Concentrated load record:		
NODNUM	The *SAP3D* node number.	I5
XLOAD	X–component of load.	F10.4
YLOAD	Y–component of load.	F10.4
ZLOAD	Z–component of load.	F10.4
Remarks:		

9.0 *GEN3D* 3–D FINITE ELEMENT EXAMPLE

9.1 *MSHGEN* Input Data:

As mentioned previously, if there are N distinct number of sections in a 3–D model, *MSHGEN* input data for each distinct section will be executed resulting in N executions of *MSHGEN*. Figure 4 shows an isometric view of the 3–D model example. It represents only one quarter of the geometry being simulated. Three typical model cross sections with their finite element discretization are shown in Figures 5 to 7. In this simple example, there are only two distinct sections; the input data file consisting of two sub-files is shown in Table 3.

9.2 *GEN3D* Input Data

The input data of the simple example required for *GEN3D* is shown in Table 4. Note that the units for the material properties and the coefficients relating the initial stresses must be compatible with the load applied to the system.

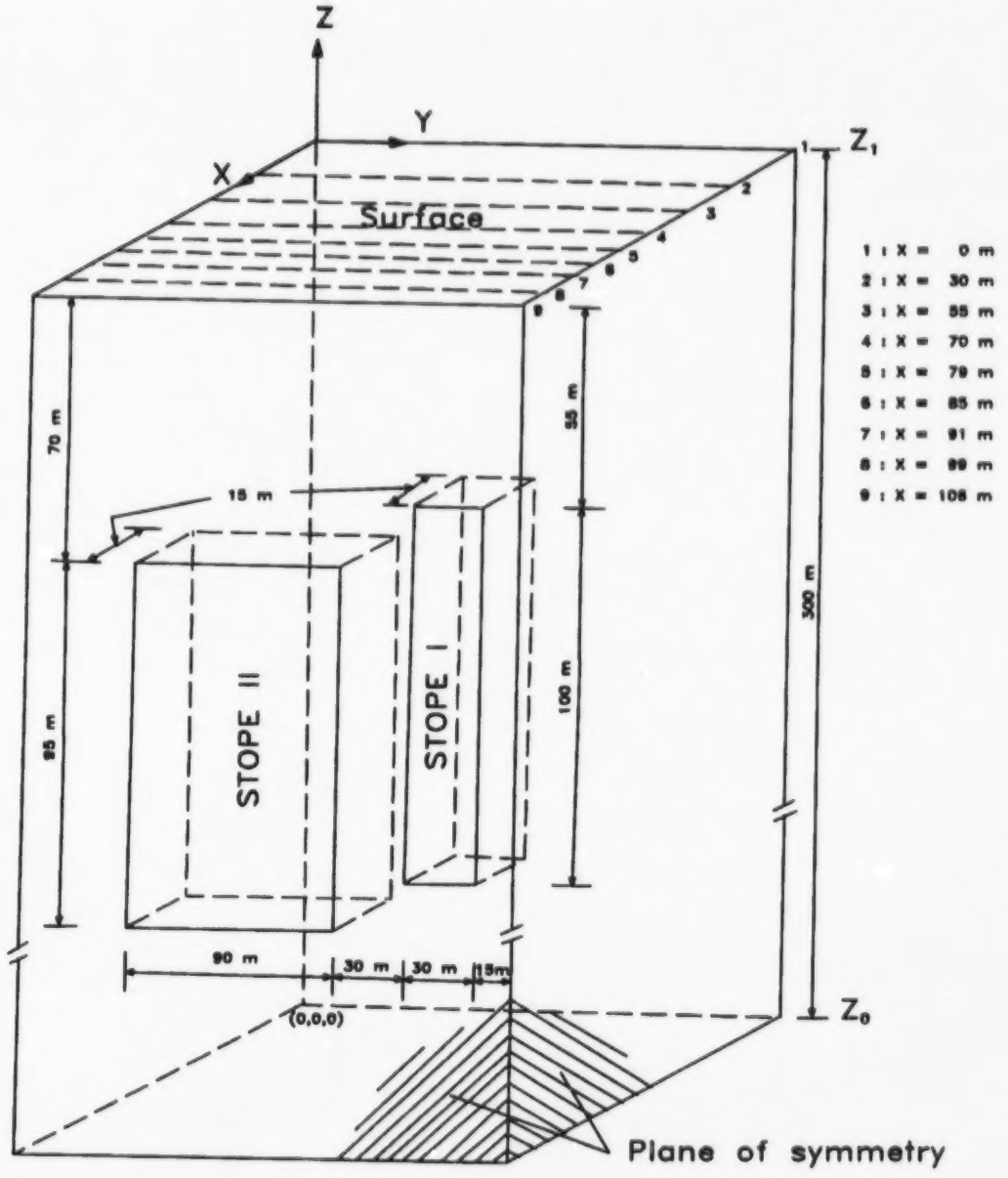


Figure 4. Isometric view of the 3–D model.

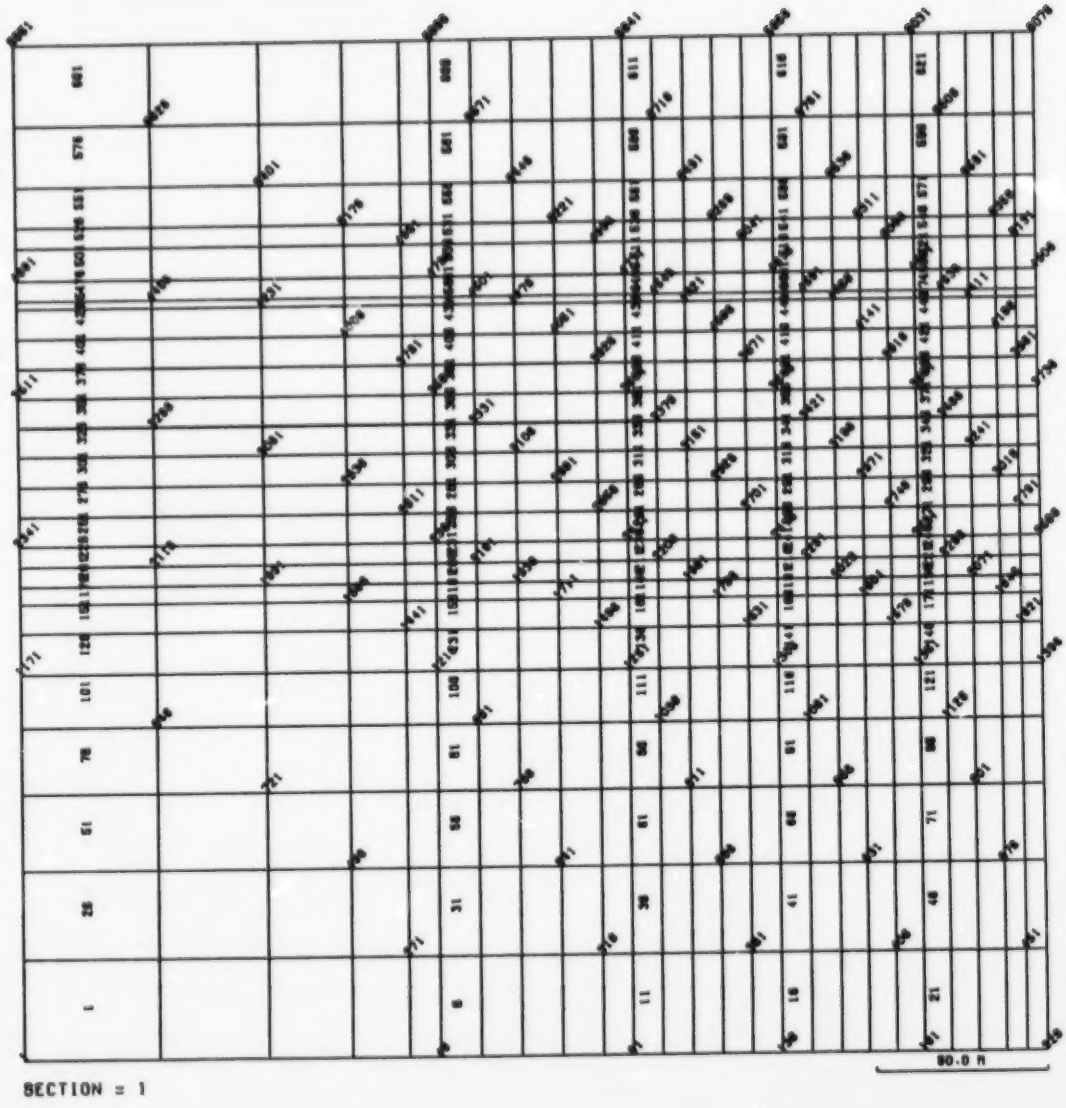


Figure 5. The 3–D Example Mesh Plot of Section 1, $X = 0$ m.

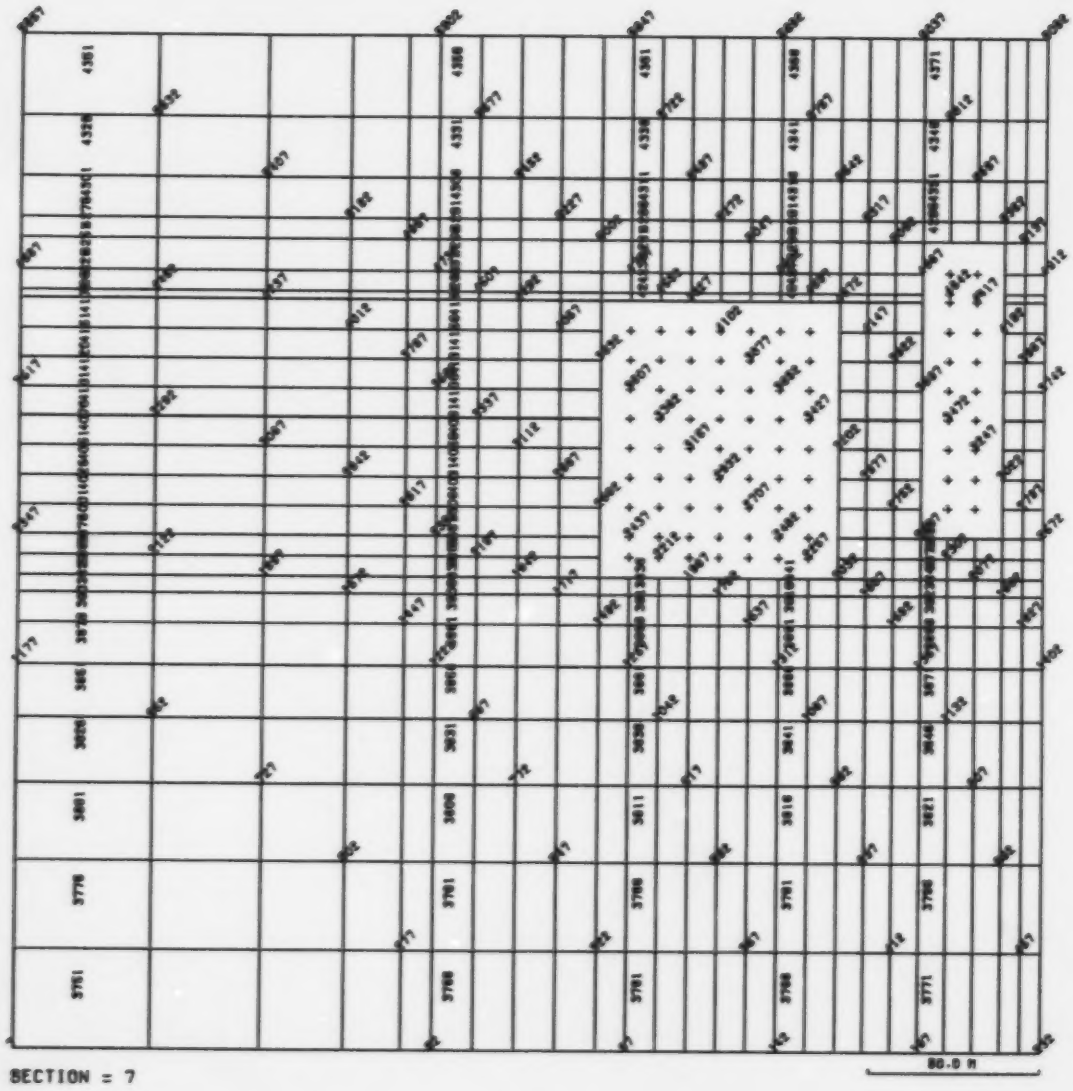


Figure 6. The 3–D Example Mesh Plot of Section 7, $X = 99$ m.

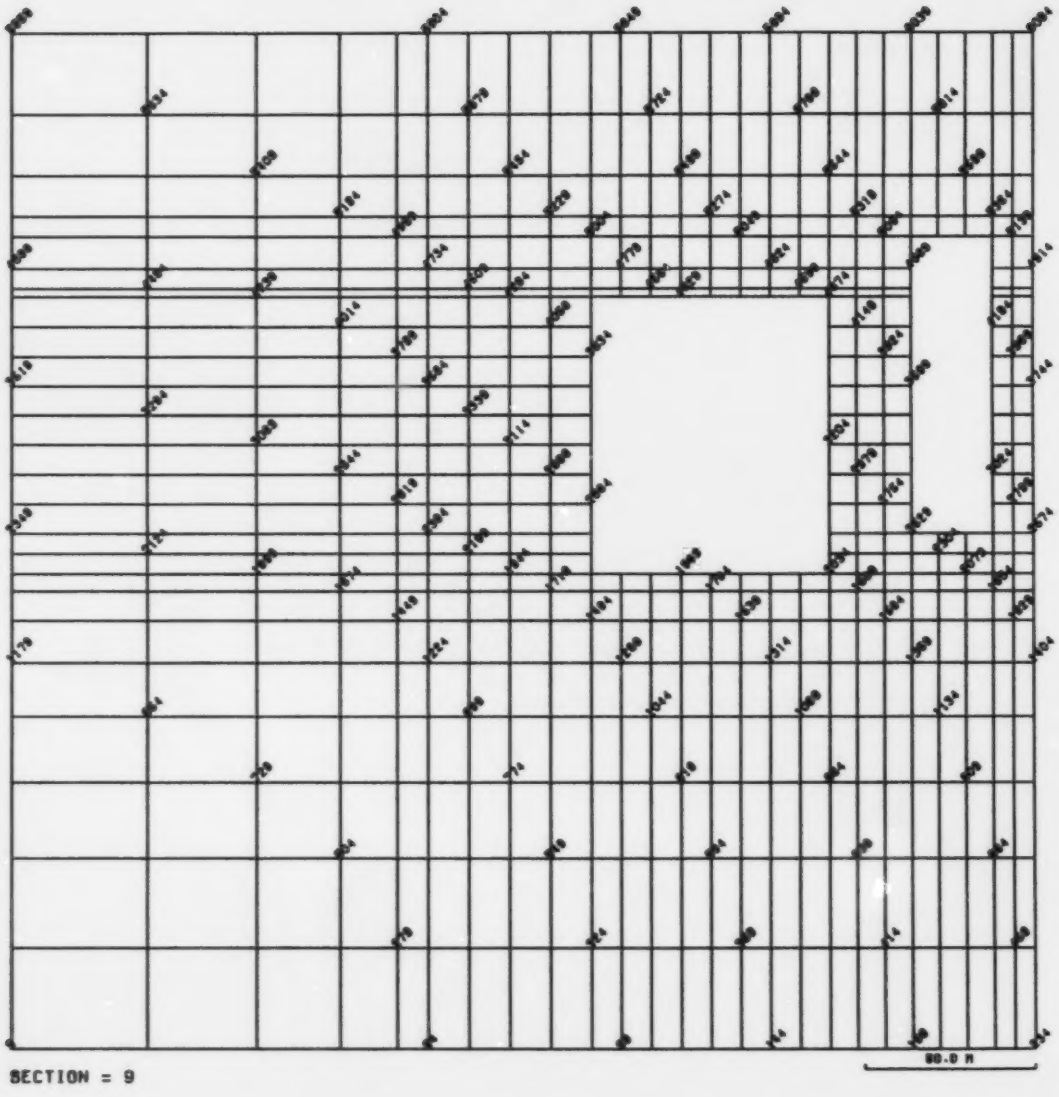


Figure 7. The 3–D Example Mesh Plot of Section 9, $X = 106$ m.

```
'MSHGEN INPUT DATA FOR GEN3D (SOLID)'   -- (sub-file #1) --
  78   35    7    5    1    0
   5    2    2    8    3    3    2
   8    2    8    3    4
   1    3  0.0000000E+00  0.0000000E+00
   2    2  0.1220000E+03  0.0000000E+00
   3    2  0.1460000E+03  0.0000000E+00
   4    2  0.1700000E+03  0.0000000E+00
   5    2  0.2400000E+03  0.0000000E+00
   6    2  0.2640000E+03  0.0000000E+00
   7    2  0.2880000E+03  0.0000000E+00
   8    3  0.3000000E+03  0.0000000E+00
   9    1  0.0000000E+00  0.1400000E+03
  10    0  0.1220000E+03  0.1400000E+03
  11    0  0.1460000E+03  0.1400000E+03
  12    0  0.1700000E+03  0.1400000E+03
  13    0  0.2400000E+03  0.1400000E+03
  14    0  0.2640000E+03  0.1400000E+03
  15    0  0.2880000E+03  0.1400000E+03
  16    1  0.3000000E+03  0.1400000E+03
  17    1  0.0000000E+00  0.1520000E+03
  18    0  0.1220000E+03  0.1520000E+03
  19    0  0.1460000E+03  0.1520000E+03
  20    0  0.1700000E+03  0.1520000E+03
  21    0  0.2400000E+03  0.1520000E+03
  22    0  0.2640000E+03  0.1520000E+03
  23    0  0.2880000E+03  0.1520000E+03
  24    1  0.3000000E+03  0.1520000E+03
  25    1  0.0000000E+00  0.2220000E+03
  26    0  0.1220000E+03  0.2220000E+03
  27    0  0.1460000E+03  0.2220000E+03
  28    0  0.1700000E+03  0.2220000E+03
  29    0  0.2400000E+03  0.2220000E+03
  30    0  0.2640000E+03  0.2220000E+03
  31    0  0.2880000E+03  0.2220000E+03
  32    1  0.3000000E+03  0.2220000E+03
  33    1  0.0000000E+00  0.2400000E+03
  34    0  0.1220000E+03  0.2400000E+03
  35    0  0.1460000E+03  0.2400000E+03
  36    0  0.1700000E+03  0.2400000E+03
  37    0  0.2400000E+03  0.2400000E+03
  38    0  0.2640000E+03  0.2400000E+03
  39    0  0.2880000E+03  0.2400000E+03
  40    1  0.3000000E+03  0.2400000E+03
  41    1  0.0000000E+00  0.3000000E+03
  42    0  0.1220000E+03  0.3000000E+03
  43    0  0.1460000E+03  0.3000000E+03
  44    0  0.1700000E+03  0.3000000E+03
  45    0  0.2400000E+03  0.3000000E+03
  46    0  0.2640000E+03  0.3000000E+03
  47    0  0.2880000E+03  0.3000000E+03
  48    1  0.3000000E+03  0.3000000E+03
  49    2  0.8500000E+02  0.0000000E+00
  50    1  0.0000000E+00  0.9800000E+02
  51    0  0.1220000E+03  0.9800000E+02
  52    0  0.1460000E+03  0.9800000E+02
  53    0  0.1700000E+03  0.9800000E+02
  54    0  0.2400000E+03  0.9800000E+02
  55    0  0.2640000E+03  0.9800000E+02
  56    0  0.2880000E+03  0.9800000E+02
  57    1  0.3000000E+03  0.9800000E+02
```

Table 3. Input Data for *MSHGEN* (continued over).

58	0	0.8500000E+02	0.1400000E+03
59	0	0.8500000E+02	0.1520000E+03
60	0	0.8500000E+02	0.2220000E+03
61	1	0.0000000E+00	0.2270000E+03
62	0	0.1220000E+03	0.2270000E+03
63	0	0.1460000E+03	0.2270000E+03
64	0	0.1700000E+03	0.2270000E+03
65	0	0.2400000E+03	0.2270000E+03
66	0	0.2640000E+03	0.2270000E+03
67	0	0.2880000E+03	0.2270000E+03
68	1	0.3000000E+03	0.2270000E+03
69	0	0.8500000E+02	0.2400000E+03
70	1	0.0000000E+00	0.2580000E+03
71	0	0.1220000E+03	0.2580000E+03
72	0	0.1460000E+03	0.2580000E+03
73	0	0.1700000E+03	0.2580000E+03
74	0	0.2400000E+03	0.2580000E+03
75	0	0.2640000E+03	0.2580000E+03
76	0	0.2880000E+03	0.2580000E+03
77	1	0.3000000E+03	0.2580000E+03
78	0	0.8500000E+02	0.3000000E+03

1	1	2	10	9	49	51	58	50	1	2	0
2	2	3	11	10	0	52	0	51	1	2	0
3	3	4	12	11	0	53	0	52	1	2	0
4	4	5	13	12	0	54	0	53	1	2	0
5	5	6	14	13	0	55	0	54	1	2	0
6	6	7	15	14	0	56	0	55	1	2	0
7	7	8	16	15	0	57	0	56	1	2	0
8	9	10	18	17	58	0	59	0	2	2	0
9	10	11	19	18	0	0	0	0	2	2	0
10	11	12	20	19	0	0	0	0	2	2	0
11	12	13	21	20	0	0	0	0	2	2	0
12	13	14	22	21	0	0	0	0	2	2	0
13	14	15	23	22	0	0	0	0	2	2	0
14	15	16	24	23	0	0	0	0	2	2	0
15	17	18	26	25	59	0	60	0	2	2	0
16	18	19	27	26	0	0	0	0	2	2	0
17	19	20	28	27	0	0	0	0	2	2	0
18	20	21	29	28	0	0	0	0	2	2	0
19	21	22	30	29	0	0	0	0	2	2	0
20	22	23	31	30	0	0	0	0	2	2	0
21	23	24	32	31	0	0	0	0	2	2	0
22	25	26	34	33	60	62	69	61	2	2	0
23	26	27	35	34	0	63	0	62	2	2	0
24	27	28	36	35	0	64	0	63	2	2	0
25	28	29	37	36	0	65	0	64	2	2	0
26	29	30	38	37	0	66	0	65	2	2	0
27	30	31	39	38	0	67	0	66	2	2	0
28	31	32	40	39	0	68	0	67	2	2	0
29	33	34	42	41	69	71	78	70	3	2	0
30	34	35	43	42	0	72	0	71	3	2	0
31	35	36	44	43	0	73	0	72	3	2	0
32	36	37	45	44	0	74	0	73	3	2	0
33	37	38	46	45	0	75	0	74	3	2	0
34	38	39	47	46	0	76	0	75	3	2	0
35	39	40	48	47	0	77	0	76	3	2	0

Table 3. Input Data for *MSHGEN* (continued over).

```
'MSHGEN INPUT DATA FOR GEN3D (OPENING)'  -- (sub-file #2) --
  78   35    7    5    1    0
   5    2    2    8    3    3    2
   8    2    8    3    4
   1    3  0.0000000E+00  0.0000000E+00
   2    2  0.1220000E+03  0.0000000E+00
   3    2  0.1460000E+03  0.0000000E+00
   4    2  0.1700000E+03  0.0000000E+00
   5    2  0.2400000E+03  0.0000000E+00
   6    2  0.2640000E+03  0.0000000E+00
   7    2  0.2880000E+03  0.0000000E+00
   8    3  0.3000000E+03  0.0000000E+00
   9    1  0.0000000E+00  0.1400000E+03
  10    0  0.1220000E+03  0.1400000E+03
  11    0  0.1460000E+03  0.1400000E+03
  12    0  0.1700000E+03  0.1400000E+03
  13    0  0.2400000E+03  0.1400000E+03
  14    0  0.2640000E+03  0.1400000E+03
  15    0  0.2880000E+03  0.1400000E+03
  16    1  0.3000000E+03  0.1400000E+03
  17    1  0.0000000E+00  0.1520000E+03
  18    0  0.1220000E+03  0.1520000E+03
  19    0  0.1460000E+03  0.1520000E+03
  20    0  0.1700000E+03  0.1520000E+03
  21    0  0.2400000E+03  0.1520000E+03
  22    0  0.2640000E+03  0.1520000E+03
  23    0  0.2880000E+03  0.1520000E+03
  24    1  0.3000000E+03  0.1520000E+03
  25    1  0.0000000E+00  0.2220000E+03
  26    0  0.1220000E+03  0.2220000E+03
  27    0  0.1460000E+03  0.2220000E+03
  28    0  0.1700000E+03  0.2220000E+03
  29    0  0.2400000E+03  0.2220000E+03
  30    0  0.2640000E+03  0.2220000E+03
  31    0  0.2880000E+03  0.2220000E+03
  32    1  0.3000000E+03  0.2220000E+03
  33    1  0.0000000E+00  0.2400000E+03
  34    0  0.1220000E+03  0.2400000E+03
  35    0  0.1460000E+03  0.2400000E+03
  36    0  0.1700000E+03  0.2400000E+03
  37    0  0.2400000E+03  0.2400000E+03
  38    0  0.2640000E+03  0.2400000E+03
  39    0  0.2880000E+03  0.2400000E+03
  40    1  0.3000000E+03  0.2400000E+03
  41    1  0.0000000E+00  0.3000000E+03
  42    0  0.1220000E+03  0.3000000E+03
  43    0  0.1460000E+03  0.3000000E+03
  44    0  0.1700000E+03  0.3000000E+03
  45    0  0.2400000E+03  0.3000000E+03
  46    0  0.2640000E+03  0.3000000E+03
  47    0  0.2880000E+03  0.3000000E+03
  48    1  0.3000000E+03  0.3000000E+03
  49    2  0.8500000E+02  0.0000000E+00
  50    1  0.0000000E+00  0.9800000E+02
  51    0  0.1220000E+03  0.9800000E+02
  52    0  0.1460000E+03  0.9800000E+02
  53    0  0.1700000E+03  0.9800000E+02
  54    0  0.2400000E+03  0.9800000E+02
  55    0  0.2640000E+03  0.9800000E+02
  56    0  0.2880000E+03  0.9800000E+02
  57    1  0.3000000E+03  0.9800000E+02
```

Table 3. Input Data for *MSHGEN* (continued over).

58	0	0.8500000E+02	0.1400000E+03
59	0	0.8500000E+02	0.1520000E+03
60	0	0.8500000E+02	0.2220000E+03
61	1	0.0000000E+00	0.2270000E+03
62	0	0.1220000E+03	0.2270000E+03
63	0	0.1460000E+03	0.2270000E+03
64	0	0.1700000E+03	0.2270000E+03
65	0	0.2400000E+03	0.2270000E+03
66	0	0.2640000E+03	0.2270000E+03
67	0	0.2880000E+03	0.2270000E+03
68	1	0.3000000E+03	0.2270000E+03
69	0	0.8500000E+02	0.2400000E+03
70	1	0.0000000E+00	0.2580000E+03
71	0	0.1220000E+03	0.2580000E+03
72	0	0.1460000E+03	0.2580000E+03
73	0	0.1700000E+03	0.2580000E+03
74	0	0.2400000E+03	0.2580000E+03
75	0	0.2640000E+03	0.2580000E+03
76	0	0.2880000E+03	0.2580000E+03
77	1	0.3000000E+03	0.2580000E+03
78	0	0.8500000E+02	0.3000000E+03

1	1	2	10	9	49	51	58	50	1	2	0
2	2	3	11	10	0	52	0	51	1	2	0
3	3	4	12	11	0	53	0	52	1	2	0
4	4	5	13	12	0	54	0	53	1	2	0
5	5	6	14	13	0	55	0	54	1	2	0
6	6	7	15	14	0	56	0	55	1	2	0
7	7	8	16	15	0	57	0	56	1	2	0
8	9	10	18	17	58	0	59	0	2	2	0
9	10	11	19	18	0	0	0	0	2	2	0
10	11	12	20	19	0	0	0	0	2	2	0
11	12	13	21	20	0	0	0	0	2	1	0
12	13	14	22	21	0	0	0	0	2	2	0
13	14	15	23	22	0	0	0	0	2	2	0
14	15	16	24	23	0	0	0	0	2	2	0
15	17	18	26	25	59	0	60	0	2	2	0
16	18	19	27	26	0	0	0	0	2	2	0
17	19	20	28	27	0	0	0	0	2	2	0
18	20	21	29	28	0	0	0	0	2	1	0
19	21	22	30	29	0	0	0	0	2	2	0
20	22	23	31	30	0	0	0	0	2	1	0
21	23	24	32	31	0	0	0	0	2	2	0
22	25	26	34	33	60	62	69	61	2	2	0
23	26	27	35	34	0	63	0	62	2	2	0
24	27	28	36	35	0	64	0	63	2	2	0
25	28	29	37	36	0	65	0	64	2	2	0
26	29	30	38	37	0	66	0	65	2	2	0
27	30	31	39	38	0	67	0	66	2	1	0
28	31	32	40	39	0	68	0	67	2	2	0
29	33	34	42	41	69	71	78	70	3	2	0
30	34	35	43	42	0	72	0	71	3	2	0
31	35	36	44	43	0	73	0	72	3	2	0
32	36	37	45	44	0	74	0	73	3	2	0
33	37	38	46	45	0	75	0	74	3	2	0
34	38	39	47	46	0	76	0	75	3	2	0
35	39	40	48	47	0	77	0	76	3	2	0

Table 3. Input Data for *MSHGEN*.

```
'GEN3D INPUT DATA FOR 3-D MODEL'
    9    1        1.0
    1    1          0.0
    2    1         30.0
    3    1         55.0
    4    1         70.0
    5    1         79.0
    6    1         85.0
    7    2         91.0
    8    2         99.0
    9    2        106.0
 m   TEK    50.        0.07
    0.0       0   9        0.07       45.0    0    0
'SAP3D TITLE NAME FOR THE 3-D MODEL SIMULATION'
    3    1    1    1    0    1    1    2
-12.348          0.04116
-16.464          0.05488
 -8.232          0.02744
  0.0            0.0
  0.0            0.0
  0.0            0.0
    1          40000.0            0.25          0.02744
    2          40000.0            0.25          0.02744
    3          30000.0            0.25          0.02744
```

Table 4. Input Data for *GEN3D*.

9.3 Initial Stress Coefficient Evaluation

The origin of the coordinate system in this example (Figure 4) is located at the centre of the model ($X = Y = Z = 0$). To simplify the evaluation of the initial or far field stress coefficients, a step by step calculation for the given example is provided below :-

In the Canadian shield, it is known that the horizontal stress is greater than the vertical stress. The far field stress conditions are suggested as following :

$$\sigma_Z = \gamma \times Z$$

$$\sigma_X = 1.5\sigma_Z$$

$$\sigma_Y = 2.0\sigma_Z$$

where σ_Z is the vertical stress at a depth of Z, and σ_X and σ_Y are the horizontal stress in the EW and NS directions respectively; γ is the unit weight of rock material.

The stress field is assumed to vary linearly with depth, (DH) *i.e.*, in the direction of Z as shown in Figure 4. The modulus of elasticity (E), the Poisson's ratio (ν) and the unit weight of rock material (γ) is assumed to be 40.0 GPa, 0.25 and 0.02744 MN/m^3 or MPa/m respectively. Also, the continuum mechanics convention *i.e.*, the compressive stress negative ($-$) has been used.

$$\sigma_Z = AZ + BZ \times Z = \gamma \times Z$$

$$\sigma_Y = AY + BY \times Z = 2.0\sigma_Z$$

$$\sigma_X = AX + BX \times Z = 1.5\sigma_Z$$

$$\tau_{XY} = \tau_{YZ} = \tau_{ZX} = 0.0$$

(a) Evaluate coefficients AZ and BZ

(1) When $Z_0 = 0.0$ m, $DH = 300$ m $= Z_1$

$$\sigma_Z = AZ + BZ \times Z_0 = -\gamma \times Z_1$$

$$AZ = \sigma_Z = -\gamma \times Z_1$$

$$= -0.02744 \times 300.0$$

$$= -8.232$$

(2) When $Z_1 = 300$ m, *i.e.*, on the surface of the model, $\sigma_Z = 0.0\ MPa$

$$AZ + BZ \times Z_1 = 0.0$$

$$AZ + BZ \times (300.0) = 0.0$$

$$-8.232 + BZ \times (300.0) = 0.0$$

$$BZ = 8.232/300.0 = 0.02744$$

(b) Evaluate coefficients AX and BX

(1) When $Z_0 = 0.0$ m

$$AX + BX \times Z_0 = 1.5\sigma_Z = 1.5(-8.232 + 0.02744 \times Z_0)$$

$$AX = 1.5 \times (-8.232)$$

$$AX = -12.348$$

(2) When $Z_1 = 300$ m (*i.e.*, on the surface)

$$AX + BX \times Z_1 = 1.5\sigma_Z = 0.0$$

$$-12.348 + BX \times (300.0) = 0.0$$

$$BX = 12.348/300.0 = 0.04116$$

(c) Evaluate coefficients AY and BY

(1) When $Z_0 = 0.0$ m

$$AY + BY \times Z_0 = 2.0\sigma_Z = 2.0(-8.232 + 0.02744 \times Z_0)$$

$$AY = 2.0 \times (-8.232)$$

$$AY = -16.464$$

(2) When Z_1 = 300 m (*i.e.*, on the surface)

$$AY + BY \times Z_1 = 0.0$$

$$-16.464 + BY \times (300.0) = 0.0$$

$$BY = 16.464/300.0 = 0.05488$$

Summary :

$$AX = -12.348; \quad BX = 0.04116$$

$$AY = -16.464; \quad BY = 0.05488$$

$$AZ = -8.232; \quad BZ = 0.02744$$

$$AXY = BXY = AXZ = BXZ = AYZ = BYZ = 0.0$$

10.0 *GEN3D* COMMAND PROCEDURE

A large portion of input data MSHIN required by *GEN3D* has been created by *MSHGEN*. *GEN3D* uses the MSHIN data file and merge with additional input information GENIN to produce an input data file SAPIN acceptable by *SAP3D* [3,4].

To facilitate the use of *GEN3D*, a VAX-11/750 command procedure has been written. It prompts the user for the name of MSHIN data file, GENIN data file, SAPIN output data file and, gives the user two options of plotting device (*i.e.*, "TEK" or "CAL") to select if mesh plot is desired. The command procedure is listed in Appendix B.

The command procedure does the following:

1) The user is prompted for the name of the input MSHIN data file. The procedure checks that the files exist.

2) The user is prompted for the name of the input GENIN data file name. The procedure checks that the files exist.

3) The user is prompted for the name of the output SAPIN data file name.

4) The user is asked if mesh plot is required (Y/N) ? If answer is "N" then execute GEN3DTEK.EXE.

5) If mesh plot is required the user is prompted for plotting device name *i.e.*, "TEK" or "CAL".

6) If "CAL" is specified on 5), then execute GEN3DCAL.EXE.

7) If "TEK" is specified on 5), then the user is prompted for TEKOUT plotting file name and then execute GEN3DTEK.EXE.

11.0 REFERENCES

1. Toews. N.A., Yu, Y.S.; "SAP2D documentation (1975 version) 2–D linear Elastic finite element computer system"; Division Report MRP/MRL 75-109 (TR); Mining Research Laboratories, CANMET, Energy, Mines & Resources CANADA; Ottawa; December 1975.

2. Toews. N.A., Yu, Y.S. and Wong, A.S.; "MSHGEN documentation (VAX-11/750 version) – A mesh generating program for finite element analysis of two dimensional structures"; Division Report MRP/MRL 85-32 (TR); Mining Research Laboratories, CANMET, Energy, Mines & Resources CANADA; Ottawa; February 1985.

3. Toews. N.A., Yu, Y.S. and Granz, R.; "Documentation of GEN3D (A 3–D mesh generating program for SAP3D)"; Division Report MRP/MRL 75-89 (TR); Mining Research Laboratories, CANMET, Energy, Mines & Resources CANADA; Ottawa; December 1975.

4. Toews. N.A., Yu, Y.S. and Wong, A.S.; "SAP3D documentation – A 3–D linear elastic finite element program (CRAY-1S version)"; Division Report MRP/MRL 89-07 (TR); Mining Research Laboratories, CANMET, Energy, Mines & Resources CANADA; Ottawa; May 1989.

5. Toews. N.A., Yu, Y.S. and Wong. A.S.; "SAP2D documentation (VAX-11/750 version) 2–D linear Elastic finite element program"; Division Report MRP/MRL 85-35 (TR); Mining Research Laboratories, CANMET, Energy, Mines & Resources CANADA; Ottawa; August,1985.

APPENDIX A

Uniformly Distributed Surface Load And Codes For Face Identification

A positive surface load acts in the direction of the outward normal of an odd numbered element face (*i.e.*, 1,3 or 5) and along the inward normal of an even–numbered element face as shown in Figure 8.

If the uniformly distributed surface loading is input as a positive quantity then it describes pressure loading on faces 2,4 or 6 and the tensile loading on face 1,3 or 5. If it is input as a negative quantity then it describes tensile loading on faces 2, 4 or 6 and pressure on faces 1, 3 or 5.

The finite element used in the *SAP3D* is defined by 8 nodes. Each node has 3 degrees of freedom namely, a displacement in the X, Y and Z directions. Figure 9 shown a typical 3–D finite element.

Program data for each element includes the numbers of the 8 nodes defining the element. The order in which the presented is significant. The order must be cyclic, as shown in Figure 9. The order of the nodes determines a local set of coordinates which are used to define the element faces. Any node of the element may be used as the first node; a local set of axes, a, b, c must then be associated with the nodes as shown in Figure 9. The element faces then are given a code number as given in Figure 9. The centre of the element, which is defined arbitrarily by averaging the X, Y, and Z coordinates of the 8 element nodes, is identified the same code as 0. The identification of faces is required to facilitate the input of distributed load.

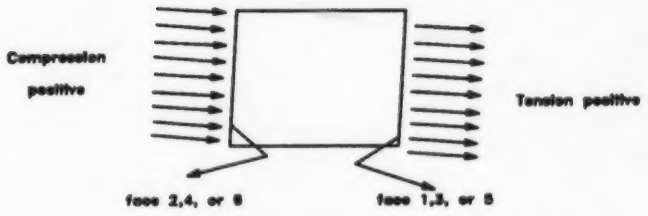
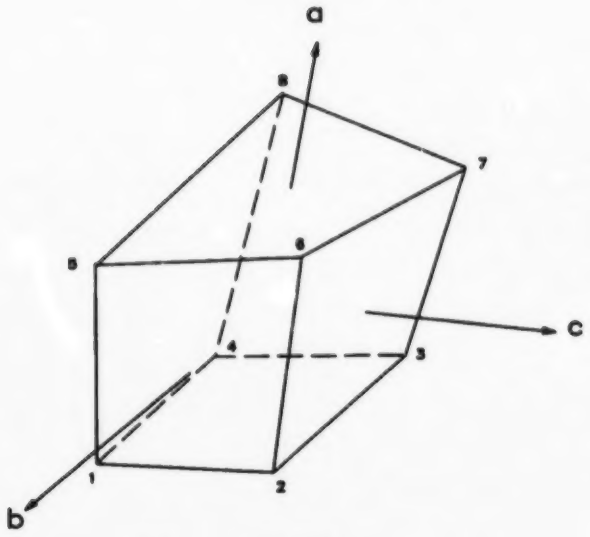


Figure 8. Sign convention for surface loads.



Code	Face Nodes
0	Centre of element
1	1 2 6 5
2	3 4 8 7
3	2 3 7 6
4	4 1 5 8
5	5 6 7 8
6	4 3 2 1

Figure 9. Typical finite element and codes for face identification.

APPENDIX B – GEN3D COMMAND PROCEDURE

```
$ ! *** GEN3D COMMAND PROCEDURE ***
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "YOU ARE RUNNING THE GEN3D COMMAND PROCEDURE"
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "DO YOU WANT TO CHANGE DEFAULT DIRECTORY ?"
$ INQUIRE CHDIR "  (Y/N) ? "
$ IF CHDIR.EQS."N" THEN GOTO CONTC1
$ INQUIRE DEFDIR "  INPUT DEFAULT DIRECTORY - [-.ABC]"
$ DEFDIR = F$PARSE("'DEFDIR'",,,"DIRECTORY")
$ SET DEF 'DEFDIR'
$ DIR
$ !
$CONTC1:
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "THE INPUT FILES REQUIRED ARE:"
$ WRITE SYS$OUTPUT "     1) MSHIN FROM MSHGEN DATA - MSHIN"
$ WRITE SYS$OUTPUT "     2) GEN3D INPUT DATA       - GENIN"
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "THE MESH OUTPUT FILE FOR SAP3D - SAPIN"
$ WRITE SYS$OUTPUT "THE PLOT FILE PRODUCED IS - GEN3D PLOT FILE"
$ !
$AGAINC1:
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "INPUT MSHIN DATA FILE"
$ INQUIRE MSHN "DEFAULT - MSHIN.DAT -"
$ IF MSHN.EQS."" THEN MSHN :="MSHIN.DAT"
$ MSHN = F$SEARCH(MSHN)
$ IF MSHN.NES."" THEN GOTO AGAINC2
$ WRITE SYS$OUTPUT "SPECIFIED MSHIN FILE DOES NOT EXIST"
$ GOTO AGAINC1
$ !
$AGAINC2:
$ !
$ ASSIGN 'MSHN' MSHIN
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "INPUT GEN3D INPUT DATA FILE"
$ INQUIRE GEN3N "DEFAULT - GEN3DIN.DAT -"
$ IF GEN3N.EQS."" THEN GEN3N := "GEN3DIN.DAT"
$ GEN3N = F$SEARCH(GEN3N)
$ IF GEN3N.NES."" THEN GOTO AGAINC3
$ WRITE SYS$OUTPUT "SPECIFIED GEN3D INPUT DATA FILE DOES NOT EXIST"
$ GOTO AGAINC2
$ !
$AGAINC3:
```

```
$ !
$ ASSIGN 'GEN3N' GENIN
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "INPUT GEN3D OUTPUT FILE FOR SAP3D"
$ INQUIRE SAP3N "DEFAULT - SAP3DIN.DAT -"
$ IF SAP3N.EQS."" THEN SAP3N := "SAP3DIN.DAT"
$ SAP3N = F$PARSE(SAP3N,,,,"SYNTAX_ONLY")
$ IF SAP3N.NES."" THEN GOTO AGAINC4
$ WRITE SYS$OUTPUT "BAD FILE NAME"
$ GOTO AGAINC3
$ !
$AGAINC4:
$ !
$ ASSIGN 'SAP3N' SAPIN
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "INPUT PLOTTING DEVICE :-"
$ WRITE SYS$OUTPUT "  TEK = TEKTRONIX 4014; CAL = CALCOMP 1042"
$ INQUIRE PLTDEV "  DEFAULT - TEK"
$ IF PLTDEV.EQS."CAL" THEN GOTO NEXTC1
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "INPUT GEN3D PLOT FILE"
$ INQUIRE PLOT "DEFAULT - PLOTFILE.TEK -"
$ IF PLOT.EQS."" THEN PLOT := "PLOTFILE.TEK"
$ ASSIGN 'PLOT' TEKOUT
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "PERFORM TEKTRONIX 4014 GEN3D PLOT"
$ WRITE SYS$OUTPUT " "
$ !
$ RUN DISK$USER:[AHSOO.SOURCE]GEN3DTEK
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "TEKTRONIX 4014 GEN3D PLOT COMPLETE"
$ WRITE SYS$OUTPUT " "
$ !
$ GOTO NEXT
$ !
$NEXTC1:
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "PERFORM CALCOMP 1042 GEN3D PLOT"
$ WRITE SYS$OUTPUT " "
$ ASSIGN SYS$COMMAND FOR005
$ !
$ RUN DISK$USER:[AHSOO.SOURCE]GEN3DCAL
$ !
$ WRITE SYS$OUTPUT " "
$ WRITE SYS$OUTPUT "CALCOMP 1042 GEN3D PLOT COMPLETE"
$ WRITE SYS$OUTPUT " "
$ !
$NEXT:
$ !
$FINISH:
```